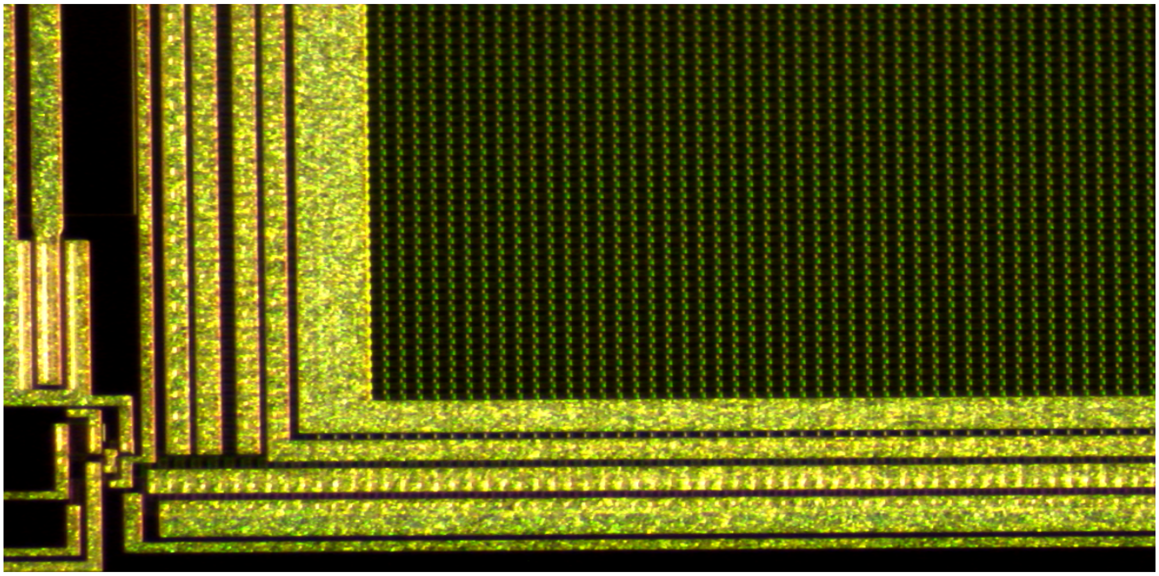
AST-305 Fall 2021: Observational Astronomy

7-9pm, Tuesdays and Thursdays (or at least that's what the college thinks!)



Instructor: **Dipankar Maitra**

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Email: maitra_dipankar@wheatoncollege.edu (best way to reach me)

Office hours: MWF 11am-1pm, or come in when door is open, or email

Course Goals and Student Objectives

• Learn various techniques used in astronomy to study a wide range of celestial objects and celestial phenomenon, over a wide wavelength range.

• Learning how to analyze multiwavelength data, visualize and interpret results, and present conclusions in the form of scientific reports.

By the end of this semester, you should be able to:

• Analyze data from a wide range of astronomical instruments, and know the right observational approach for a given astronomical problem.

• Select the right tool from your problem-solving toolbox to interpret, visualize, and present the data in the simplest, statistically sound, and most straightforward way.

<u>Textbook:</u> *None in particular as we will be covering a very wide range of topics.* I will post on the onCourse website various research papers as well as observing manuals for various instruments that are needed for different projects.

<u>*Daily class/lab structure:*</u> You will work individually or in groups of two to observe,

analyze observed or archival data as required by the project, and prepare your reports. **Since the universe does not care about our class times, be prepared to do your observations at odd hours.** I will get you keys to the astronomy lab (SC 1344) and the observatory where you can come to work 24/7. I will obviously be around during the class hours (Tu and Th, 7-9pm) to help you with your projects, but you have to plan on working predominantly outside these hours.

Getting started with Linux: Astronomers use the Linux operating system for most of their work. Linux is free, fun, and efficient! While we need Windows (unfortunately) to do some stuff, we will be using Linux predominantly in the class.

In order to get a basic idea of linux and how to work in a linux environment, we will do an intense crash course during the first week and half, and earn a badge (that you can mention in your resume later on while applying for job … an official recognition that you have basic linux familiarity!). Earning the badge will add 5% to your final grade.

Collaboration: Often you will work in groups of two for the larger projects. The groups will be fluid and you should change partners for every new big project. This is so that you are not stuck with someone for the whole semester, you get to make friends with more people, and learn to work collaboratively with a wide range of people.

Report submission: Reports are expected to be in a format similar to peer-reviewed journals like *The Astrophysical Journal*, *Science*, or *Nature*. I encourage either using LaTex or a shared google document to prepare the report. Especially, *users of LaTex formatting will receive an extra credit point for every report made in LaTex!* Sample report and LaTex templates are on onCourse. ***Final report must be in PDF format.***

Grading

Your final course grade will be based on the following:

Item	Weight (% of final grade)
Completing the linux badge	5
Homeworks and in-class tutorials	35
Various projects	60

Additionally, I may throw in some extra-credit challenges from time to time.

Grading Scale
You will not be graded on a curve. The absolute scale below is designed, in part, to encourage you to work together. Please help one another inside and outside of class!

Grade	+		-
A	>96	92	87-92
B	84-87	81-84	77-81
C	72-77	67-72	63-67
D	60-63	55-60	50-55
F	<50		

Policies

Data collection: Since clear weather cannot be guaranteed, I have put enough buffer-time in the projects that require collecting new data.

- Please make best use of the clear nights. If a project is for 4 weeks, say, and you haven't been able to collect any data during the first 2 weeks, either due to weather or instrument failure, come and talk to me.
- Calibration data (e.g. flats, darks, biases) taken within +/- two weeks of taking the science data will be acceptable, but any further delay will cause you to lose points (and also affect the accuracy of your science results).
- The time allocated to any project includes time for data acquisition (if any), analysis, visualizations, and report submission. Only one report per team needs to be submitted via email.

Using iTelescope: You will need to fill out a "Wheaton iTelescope Observing Proposal" form. This is to ensure (a) efficient use of available resources, (b) advanced planning for success, and (c) make the best use of expensive observing time on iTelescope. Here is a link to the form:

https://goo.gl/forms/mhnnlqzZuuqC9ZN63

- Keep in mind that no project is allowed to use more than 60 imaging points. Also individual projects are not allowed on iTelescope. Team projects only.
- When planning your observation please use
  - Login: ast130
  - Password: astronomer
    - THIS ACCOUNT IS FOR PLANNING ONLY. If your proposal is approved then DM will set up an account for you and email you the details. Use that account for the actual observations.
- Allow 24 hours for DM to review your request. Requests to observe within 24

hours will almost always be declined. However email DM if you don't get a response within 48 hours of submitting the form.

Time Commitment: As emphasized earlier, the universe does not care about our class times. So be prepared to make observations during the oddest possible hours. On the other hand, you can work on the archival data on your computer from anywhere and anytime.
Please DO NOT schedule any other activities during the Tu/Th 7-9pm class time period. While we will normally be doing individual meetings during class times, we may cancel the meeting and schedule observing sessions with less than 3 hour notice (because I do not control weather). Your attendance in these events is expected.

Safety: Projects that require using the domes at night should be done with a lab/observing partner. While astronomy is generally not a high-risk science, you do need to be careful when in the observatory premises, especially during nights. Sometimes the open walkways can be slippery, especially under humid, rainy, or icy conditions. Make sure to

1. keep your cellphone with you. Wheaton emergency number is: (508) 286-3333
2. have a red flashlight with you.
3. have your lab partner standing outside when you step inside a dome.

Accommodations and Accessibility: *Wheaton is committed to ensuring equitable access to programs and services and to prohibit discrimination in the recruitment, admission, and education of students with disabilities. Individuals with disabilities requiring accommodations or information on accessibility should contact Autumn Grant - Associate Director for Accessibility Services at the Filene Center for Academic Advising and Career Services. ~ accessibility@wheatoncollege.edu or (508) 286-8215*

Mask policy: Masks or face coverings must be worn inside any Wheaton facility where others are present and outside where social distancing cannot be maintained, except where unsafe due to a medical condition or disability. All community members should bring their own mask when coming to campus, although the college does have a limited supply of masks for community members that on occasion require one. As a result of evolving guidance and research, masks with exhalation valves are not permitted. We also recommend community members to refrain from using neck gaiters as their sole face covering while research evolves on its effectiveness of limiting the spread of COVID-19.

Athletics: College policy dictates that team practice is not a legitimate excuse for missing a class. If you foresee any regular season game conflicting with your work, let me and your project partner know as soon as possible.

Tentative Calendar

<table>
<tr>
<td>August and September:</td>
<td>Basic concepts and tools of the trade:
● Image formation
○ by pinholes (Aug 31)
○ by lenses (Sep 2)
● How linux computers work (linux badge, complete by Sep 14)
● How telescopes work (Sep 7)
○ FOV, Magnification
● How detectors work (Sep 9)
● Using the Wheaton Observatory (Sep 14, 16)
● How to plan an observation, intro to iTelescope.net (Sep 21)
● How to calibrate astronomical images
○ Image reduction (Sep 23)
○ Plate solving (Sep 23)
● How to obtain brightnesses of objects of interest (Sep 28)
● Making color image (Sep 30)</td>
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<td colspan="2">Sep 14: Unix badge submission deadline.</td>
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<td>Rest of the semester</td>
<td>Working on projects. Sometimes observing. Weekly meeting to update DM on project’s progress.</td>
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<td colspan="2">Dec 10: All project reports and other course-related work needs to be submitted by the end of the day.</td>
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<td colspan="2">Please DO NOT schedule any other activities during the Tu/Th 7-9pm class time period. While we will normally be doing meetings during class times, we may cancel the meeting and schedule observing sessions with less than 6 hour notice (because I do not control weather). Your attendance in these events is expected.</td>
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List of projects (more may be added with time)

One-line Project description (Meet DM for details on each)	Maximum project duration	Points
Spectrum of Sun using LHIRES spectrometer and identifying the lines from an atlas of solar spectral lines (PDF here). The english version of the LHIRES manual starts from pg. 37 of this PDF.	1 wk	7
Spectrum of Sun using our USB spectrometer and identify the elements creating major absorption lines. [Can be done on any day, clear or cloudy!]	1 wk	7
Spectrum of a sunspot using our USB spectrometer and identify differences between regular solar spectrum and sunspot spectrum. [Only try after you have used the USB spectrometer for the 'Spectrum of Sun' project, and once you've verified that there is at least one large sunspot on the Sun.]	1 wk	7
Spectra of different regions of the Moon using our USB spectrometer and identify differences. [Only try within +/- 7 days of the Full Moon.]	1 wk	7
Spectrum of a bright star using a grating placed in front of our DSLR camera, and identify major absorption lines.	1 wk	7
Find the spectral response of some of our astronomical filters using the USB spectrometer. [Can be done anytime in our lab.]	1 wk	7
Contribute to real science: Get data on AAVSO Alert Notices [Good project for iTelescope]	2 wk	14
Image a bit of the "dark side" of the Moon (see S&T, 2018, Sep, 52) using our astro-webcams (or some other equipment), and identify the features.	1 wk	7
Determine the characteristics of one of our CCDs. This implies determining (a) the bias level, (b) finding the hot pixels, (c) studying how the dark current changes with temperature and time, (d) studying the linearity of the CCD, (e) studying the response of each pixel by illuminating it with uniform light. [Can be done anytime in our lab.]	3 wk	21
A deep narrowband image of a planetary nebula or a supernova remnant (preferably an object from Messier catalog). Choose a suitable object and consult with DM before starting. The total exposure time must be at least 1 hour. [Needs a clear, moonless night.]	1 wk	7
Observing Abell Planetaries in OIII --- S&T, 2017, July, 34. Choose a suitable object and consult with DM before starting. The total exposure time must be at least 1 hour. [Needs a clear, moonless night.]	1 wk	7
Observe Ancient Photons from AGNs --- S&T, 2018, March, 57. Choose a suitable object and consult with DM before starting. The total exposure time must be at least 1 hour. [Needs a clear, moonless night.]	1 wk	7

A deep RGB color image of a galaxy. Preferably one from Messier or Caldwell catalog; or a galaxy in collision (S&T, 2017, May, 28); or Observing Starburst Galaxies (S&T, 2018, March, 28). Choose a suitable object and consult with DM before proceeding. Total exposure must be at least an hour. [Needs a clear, moonless night.]	2 wk	14
CCD photometry of the exoplanet WASP-80b using archival data (and optionally modeling the light curve you obtained).	2 wk (+1 wk)	14 (+7)
Observing an exoplanet transit and obtaining the light curve (and optionally modeling the light curve you obtained).	3 wk (+1 wk)	21 (+7)
CCD Photometry of a black hole or neutron star X-ray binary in two wavelengths and study its evolution using archival data.	3 wk	21
Orbital period of an X-ray binary using archival X-ray data.	2 wk	14
CCD astrometry of an asteroid, or Pluto, using archival or new data (and orbit determination)	1 wk (+1 wk)	7 (+7)
Astrometry of Proxima Centauri to detect proper motion, using archival data	2 wk	14
A project of your own: Bring your ideas to the table. Consult with DM for possibilities and feasibilities	3 wk max.	21 points max

Notes:

1. While, there is no upper limit on the length of you project reports,
    - All 1-week project reports should be at least 2 pages in length, including figures, tables, graphs, and references.
    - All 2-week project reports should be at least 3 pages in length, including figures, tables, graphs, and references.
    - All 3-week project reports should be at least 4 pages in length, including figures, tables, graphs, and references.

2. You cannot work on more than two projects simultaneously.